Organ specific averaged SAR in a realistic environment at 950 MHz

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INTRODUCTION

The whole-body-averaged specific absorption rate (SAR_{wb}) can be determined either for specific deterministic configurations, or statistically for realistic environments [1]. Up till now the organ specific averaged (OSA) SAR cannot be assessed statistically for realistic environments. The OSA SAR is important because it gives more information about where in the body the energy of electromagnetic fields (EMFs) is absorbed. In this paper a method to assess the OSA SAR statistically in realistic environments is proposed for the first time.

MATERIALS AND METHODS

This study aims to determine the OSA SAR for far-field exposure in a realistic environment. To do this we make use of the statistical multipath tool developed by Vermeeren et al. [1], which we extended for realistic human body phantoms and their organs.
To determine an average OSA SAR for a realistic exposure scenario or environment, a large number of exposure samples are necessary. Instead of running a finite difference time domain (FDTD) simulation for each exposure sample, we first extract the fields for a limited set of incident plane waves in every point of the organ, using an organ specific mask in SEMCAD-X. These are called the basic field distributions (BFDs) [1]. Every exposure sample consists of several incident plane waves. These plane waves are approximated, using the BFDs [1]. To obtain the EMFs for the correct azimuth angle of incidence φ, a cyclic cubic spline interpolation over the BFDs is carried out. Subsequently a natural cubic spline interpolation for the inclination angle θ (using 6 sets of φ–interpolated fields) is carried out. Together with the dielectric properties of the organs, the obtained fields in the organs are used to determine the OSA SAR.
Using this approach, we can estimate the OSA SAR for all the organs in a human body phantom. To demonstrate the use of our method we have chosen the frequency of 950 MHz, which is the GSM downlink frequency. The organs under consideration in this study are the kidneys of the 6 year old virtual human family boy; these consist out of two parts: the cortex and the medulla. The dielectric properties of the kidneys and other tissues are obtained from the Gabriel database [2].

RESULTS

The BFDs in the medulla of the kidneys are calculated every 10° for the azimuth angle φ and every 5° for each inclination angle θ. Validation tests using 100 samples show that this method provides an average relative error of 0.7 % on the obtained OSA SAR compared to FDTD simulations, with a standard deviation of 0.8 % and a maximum relative error of 4.7 % for the medulla of the kidney. This error is an interpolation error since it can be reduced by using a smaller discretization step in φ or θ.
Figure 1 shows the cumulative distribution function (cdf) of the OSA SAR for the medulla of the kidneys generated using 4000 exposure samples for different exposure environments at

950 MHz. The total incident field strength is averaged over a box with dimensions 21 x 37 x 118 cm, surrounding the phantom and is equal to the corresponding reference level for the EMF at this frequency: 42.38 V/m [3].

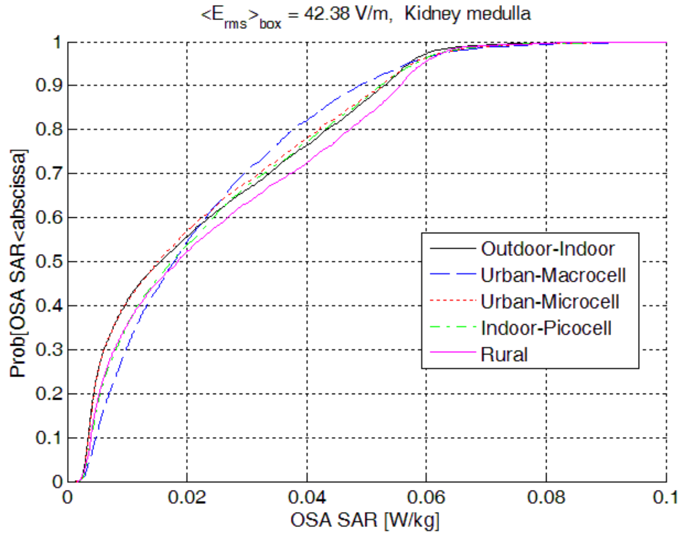

Figure 1: Cdf of exposure samples with E_{rms}= 42.38V/m, averaged over box surrounding the VFB for 4000 exposure samples in several exposure scenarios for the GSM downlink frequency of 950 MHz.

The type of environment influences the OSA SAR distribution as can be shown in figure 1, but there is a similar trend for the different environments. The mean value of the OSA SAR is highest for the 'Rural' scenario, 0.025 W/kg. The 'Urban Macro-cell' scenario accounts for the highest 99 % quantile, p_{99} = 0.074 W/kg, due to its highest average number of incoming plane waves.

CONCLUSIONS

We are able to determine the OSA SAR in a realistic environment in an efficient and accurate way. This is done by generating a statistical relevant number of exposure samples and approximating them by a combination of basic field distributions. A case study of the kidney's medulla shows that there is a dependence of the OSA SAR on the type of environment.

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